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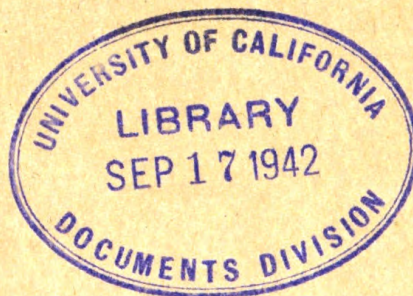
U.S. WAR DEPARTMENT

U.S. Dept. of Army
TECHNICAL MANUAL

INSTRUCTION GUIDE

PLOTTING BOARDS M3 AND M4

January 21, 1942



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No. 9-2681

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WAR DEPARTMENT,
WASHINGTON, January 21, 1942.



INSTRUCTION GUIDE

PLOTTING BOARDS M3 AND M4

Prepared under direction of the
Chief of Ordnance

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1. **General.**—*a. Purpose.*—This manual is published for the information of the using arms and services.

b. Scope.—This manual covers the underlying theory of the plotting boards M3 and M4, a detailed description of their parts, complete operating instructions, and necessary care and adjustments to be used for instructional purposes. Adjustments which may be performed by using arms personnel are described.

2. **Design and use.**—*a. General.*—(1) The plotting boards M3 and M4 are designed for use with all types of fixed seacoast artillery cannon. They provide a means for locating the target by either the two-station (horizontal base) or the one-station (vertical or self-contained base) method. The methods of locating and relocating the set-forward point in range and azimuth and determining the angular travel are the same as those employed with the 110° plotting board M1915.

(2) The plotting boards M3 and M4 differ essentially from the 110° board in that they permit continuous plotting through a field of about 200°, the center line of which corresponds approximately in azimuth with the center line of the field of fire of the gun; are equipped with optical station arms in addition to the mechanical arms; and have each station located only in one quadrant.

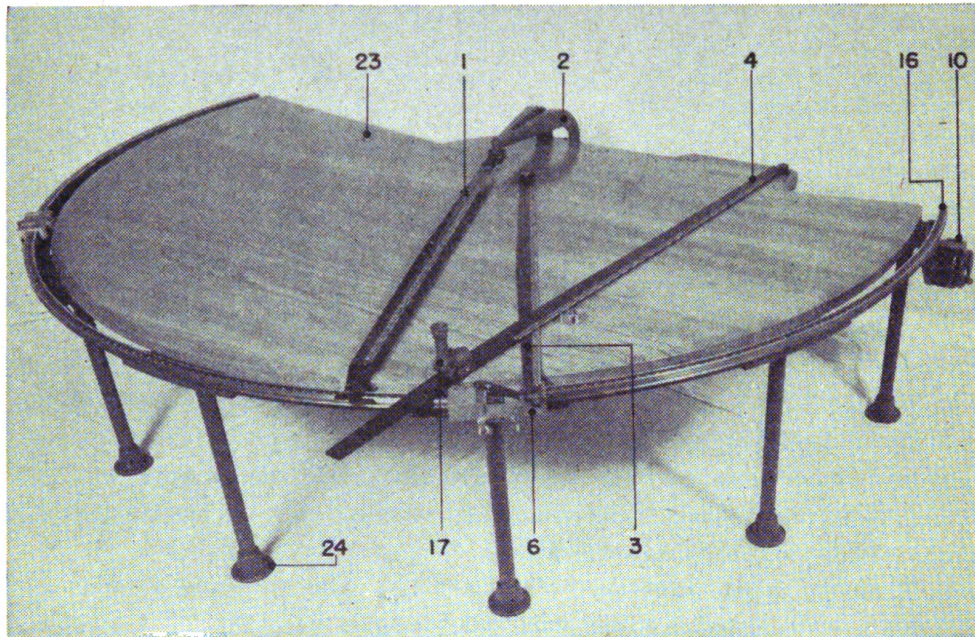
b. Comparison.—(1) The plotting board M3 is constructed to a scale of 600 yards per inch, has a plotting radius of 58⅓ inches, and the station and gun arms are graduated from 3,000 to 35,000 yards. The

*This manual supersedes TM 9-2681, July 10, 1941.

plotting board M4 is constructed to a scale of 800 yards per inch, has a plotting radius of $67\frac{1}{2}$ inches, and the station and gun arms are graduated from 4,000 to 54,000 yards.

(2) Inasmuch as the boards differ only in plotting radius and range, the instructions apply to both boards unless otherwise noted.

3. Description of major units.—The plotting boards M3 and M4 may be divided into the following units to facilitate description: plotting board and azimuth circle, directing point and gun arm, station



- | | |
|----------------------------|----------------------|
| 1. Gun arm. | 10. Indicator. |
| 2. Gun arm bracket. | 16. Azimuth circle. |
| 3. Mechanical station arm. | 17. Elbow telescope. |
| 4. Optical station arm. | 23. Dust cap. |
| 6. Index box. | 24. Leg base. |

FIGURE 1.—Plotting board M3.

centers, mechanical station arms and index boxes, optical station arms, indicator and mirror drive, and miscellaneous equipment.

a. Plotting board and azimuth circle.—(1) *Plotting board proper.*—The plotting board consists of a built-up board mounted on a rigid spider, or frame, supported on pipe legs. The legs are provided with jackscrew bases (24, fig. 1) to facilitate leveling the board and to compensate for unevenness in the floor of the plotting room.

(2) *Azimuth circle.*—An azimuth circle (16, fig. 1) is engraved on metal strips which are dovetailed into a series of segments bolted to the outer end of the spider arms. The circle is engraved and num-

bered at 1° intervals, and the mean azimuth of the gun is indicated by the graduation on the center line of the board.

b. Directing point and gun arm.—The directing point is located at the center of the azimuth circle, and the gun arm (1, fig. 1) is pivoted in the bracket (2) above this center. The gun arm is also hinged (sec. B-B, fig. 4) on a horizontal pivot to facilitate operation. A subscale (15, fig. 11) is attached to the outer extremity of the gun arm to permit reading gun azimuth to 0.05° .

c. Station centers.—(1) *Mechanical arm centers.*—(a) The base and stations are represented by sleeves, or bushings (sec. D-D, fig. 4), accurately located in azimuth and distance from the directing point. The sleeves used in conjunction with the mechanical station arms are equipped with antifriction bearings into which the pivots of the appropriate station arms are fitted for operation.

(b) Special station center plugs (sec. C-C, fig. 4) are provided for use in the event that stations are situated so close together that the customary station sleeves cannot be located without mutual interference. (See fig. 2.) Each plug is provided with an antifriction bearing for the station arm pivot and has a square boss machined on its under side. The pivot bearing is located eccentrically with respect to the boss, which provides the means for orienting the station center in either of two positions. It is essential that the coupler corresponding to the position employed be used. Failure to do this will limit the rotation of the mechanical station arm and introduce an error in tracking. An arrow, or index, is engraved on the upper surface of the plug. In use, the boss is placed in a square bushing in the station plate with the arrow pointing toward the identification mark of the station to be employed.

(2) *Optical station centers.*—The hollow pivots on the optical arms fit directly into the sleeves of the optical stations. The sleeves in these stations are machined in the upper end of the housings which contain the worm gearing for driving the mirror assemblies. (See sec. A-A, fig. 9.)

d. Mechanical station arms and index boxes.—(1) The mechanical station arms (3, fig. 11) are equipped with couplers (5), equal in length to the displacement of their respective stations from the directing point. The couplers are attached to index boxes (6) and serve to keep the station arms at all times parallel to imaginary auxiliary arms pivoted at the directing point. An arm is supplied for each mechanical station and the arms are not interchangeable between stations.

(2) The index boxes ride along the azimuth circle and are provided with subscales for reading the azimuths of the station arms to 0.05° . Two subscales are provided in each index box, one engraved and filled in with white paint, the other engraved and filled in with red paint.

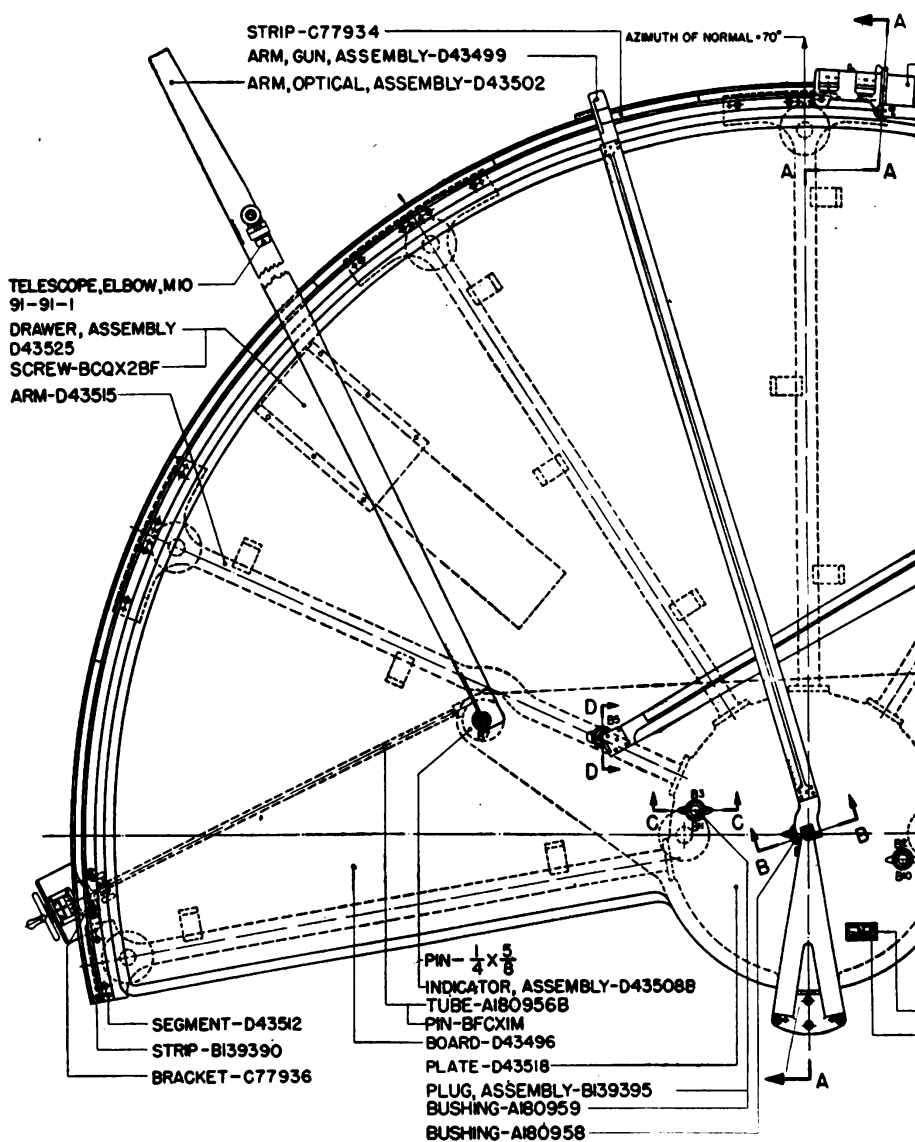
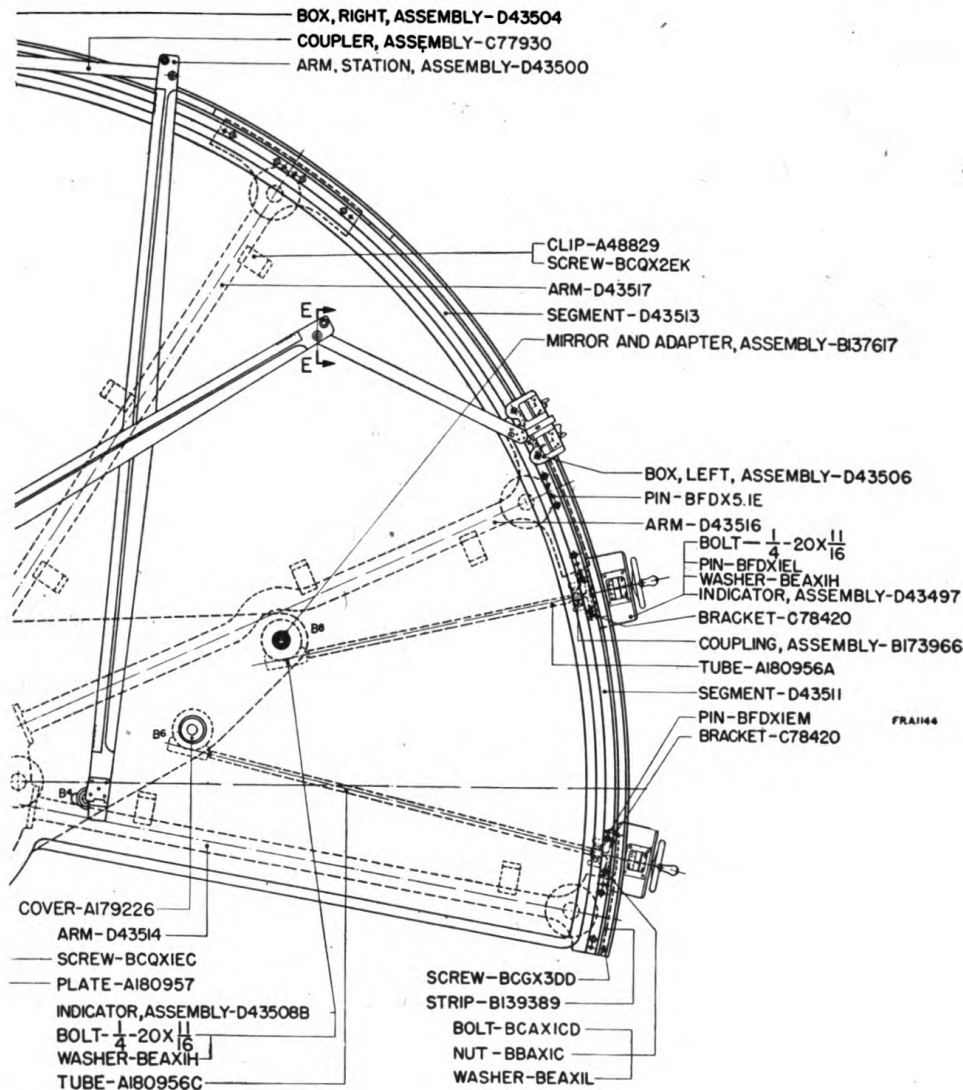


FIGURE 2.—Plotting board

The white subscale is for normal use and indicates the true azimuth of the station arm. The red subscale is used only when the station arm or coupler covers the white subscale; it indicates an azimuth 3° greater or less than true azimuth, depending upon which index box is being used. Each index box is equipped with a spring-actuated

latch (7, fig. 11) for locking the couplers, and a lever (8) for releasing the clamping shoe and thereby permitting the box to slide along the azimuth circle.

e. Optical station arms.—(1) Optical station arms (4, fig. 1) are provided to eliminate the inconvenience which would attend the use



M4, assembled view.

of the conventional coupler assembly with stations located 25 inches or more from the directing point on the board, in which case the overhang of the long couplers would interfere with the operating personnel.

(2) The number of optical arms supplied with each board depends on the number and location of the stations. The arms are interchangeable among the stations, so in no case will more than two

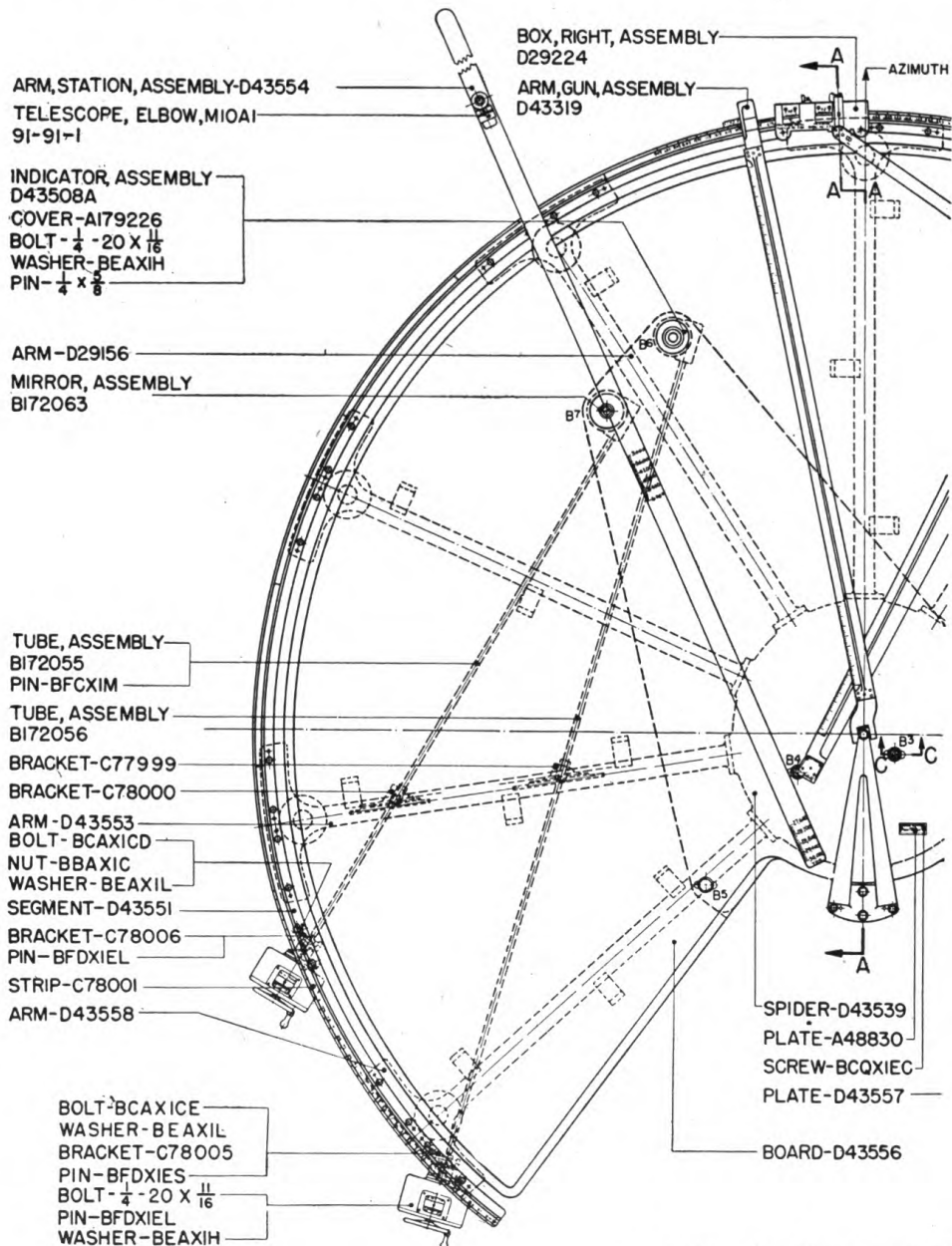
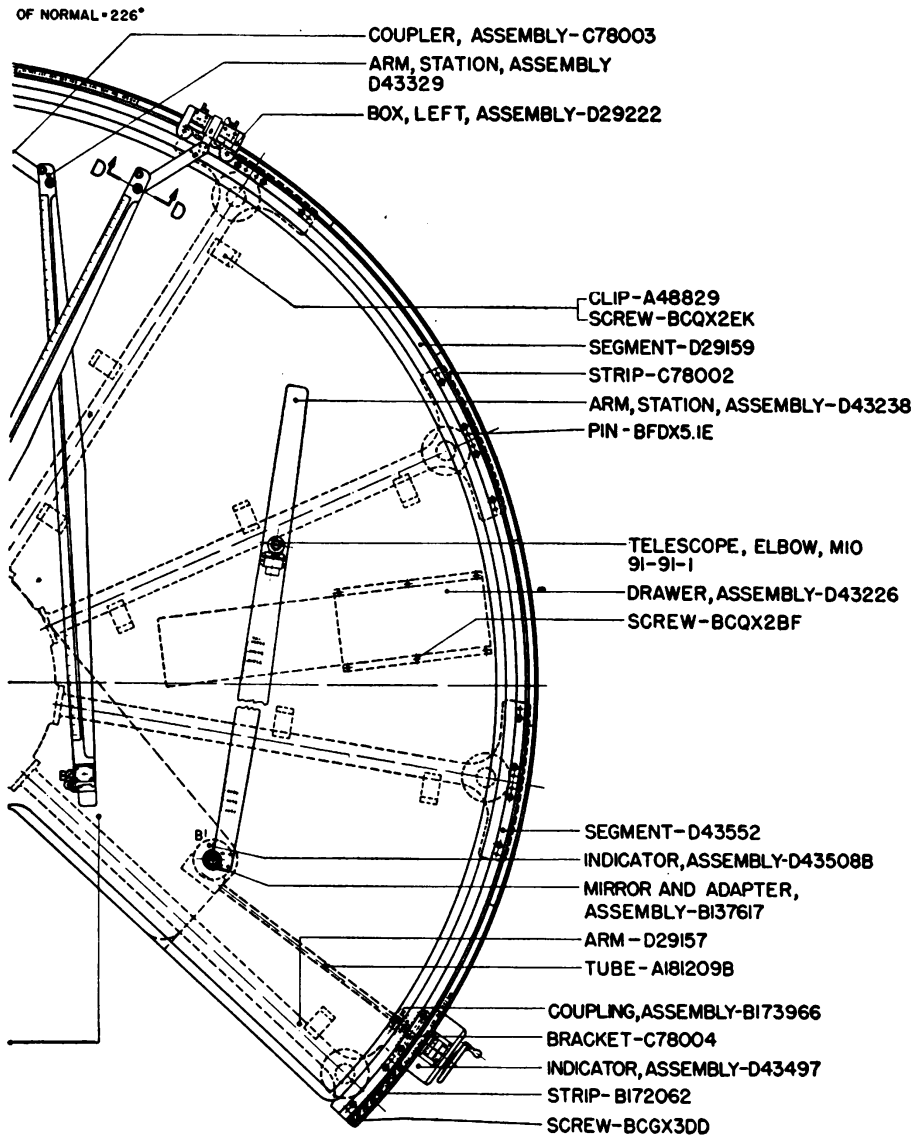


FIGURE 3.—Plotting board

standard arms be needed. However, on certain boards stations have been located in front of the directing point (fig. 3), and in these cases special arms are supplied which are not interchangeable with the standard arms.

(3) The elbow telescope M10 is used with the standard arm and the M10A1 telescope with the special arm. The two telescopes are identical except that in the M10A1 instrument the image distance



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M3, assembled view.

has been increased (fig. 6) to accommodate the decreased object distance employed with the special arm. The front end of the telescope is so constructed (fig. 5) that the sleeve (B173790) can be turned out a sufficient distance to effect this change.

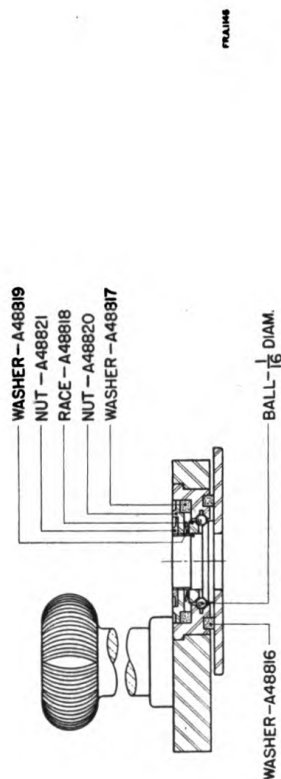
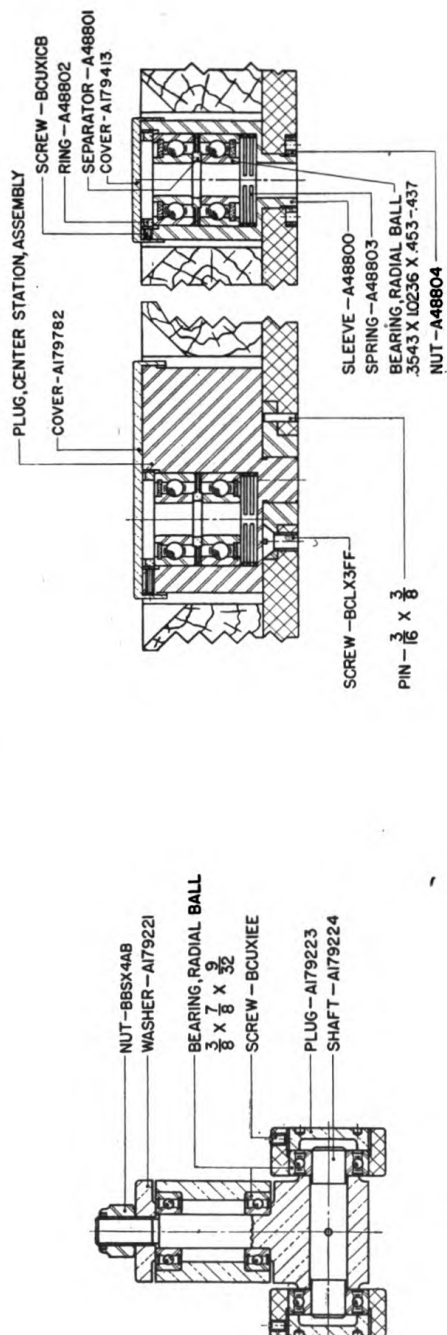


Figure 4.—Plotting boards M3 and M4, sectional views.

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SECTION A-A

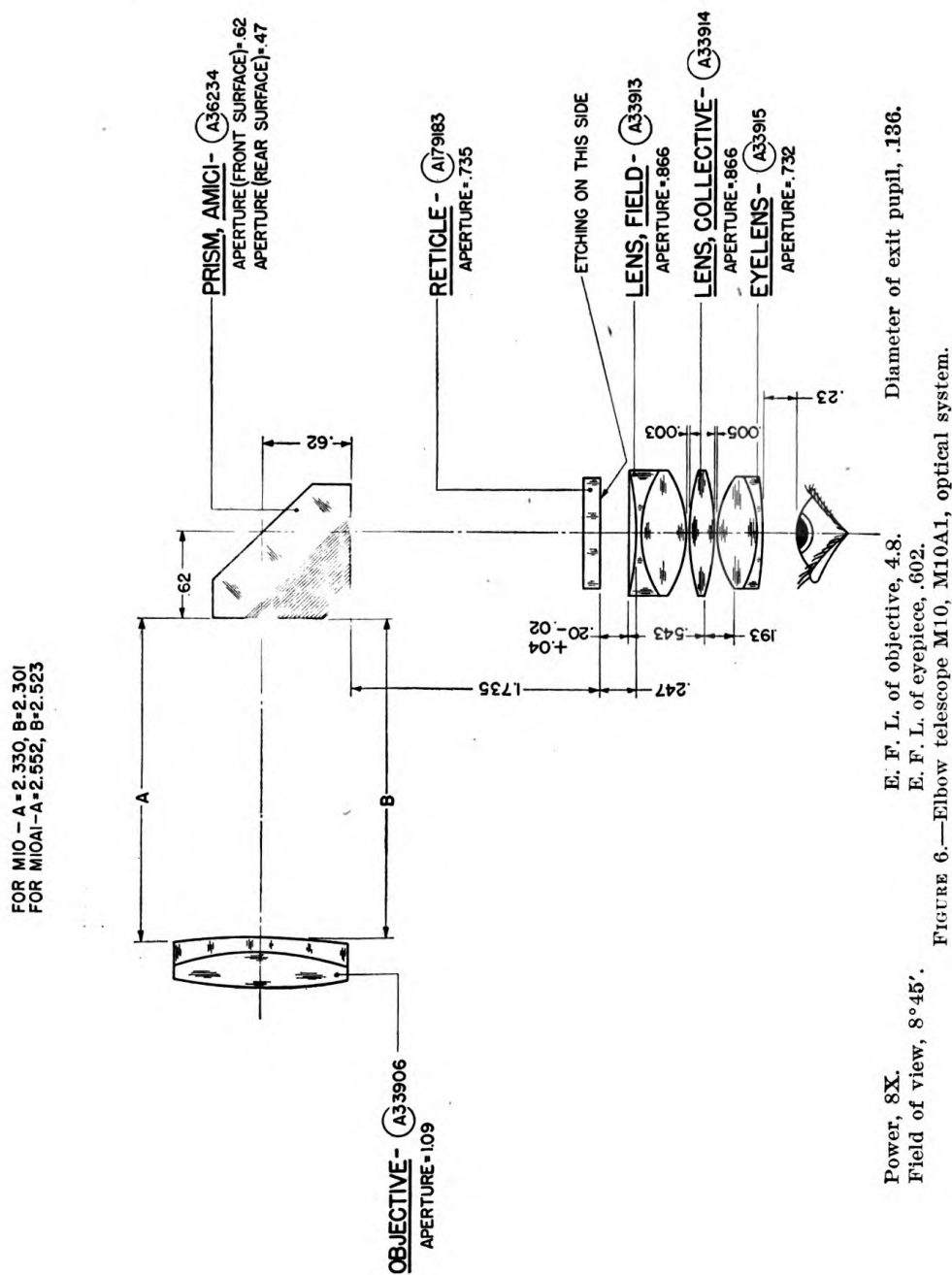


FIGURE 6.—Elbow telescope M10, M10A1, optical system.

(4) The elbow telescope is positioned accurately on the arm. A cap (B173791), which fits over the objective cell (A184440), supports a narrow vertical metal strip, the front surface of which is painted white. In use, the arm is positioned with respect to the mirror (fig. 7) until the vertical black line on the reticle appears to be superimposed upon the reflected image of the broad white line on the strip across the objective. This condition will prevail only when the line of sight is normal to the mirror. In this position the fiducial edge of the arm will be set to the azimuth indicated on the indicator (10, fig. 13), which is connected to the mirror by means of the tube (19) and worm and gear shown in figure 9.

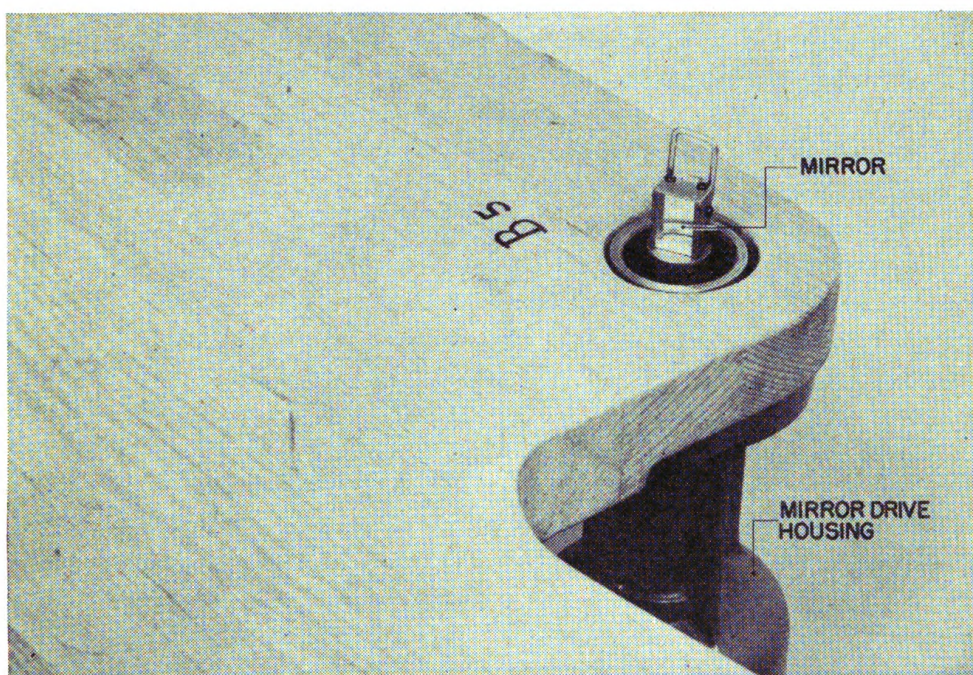


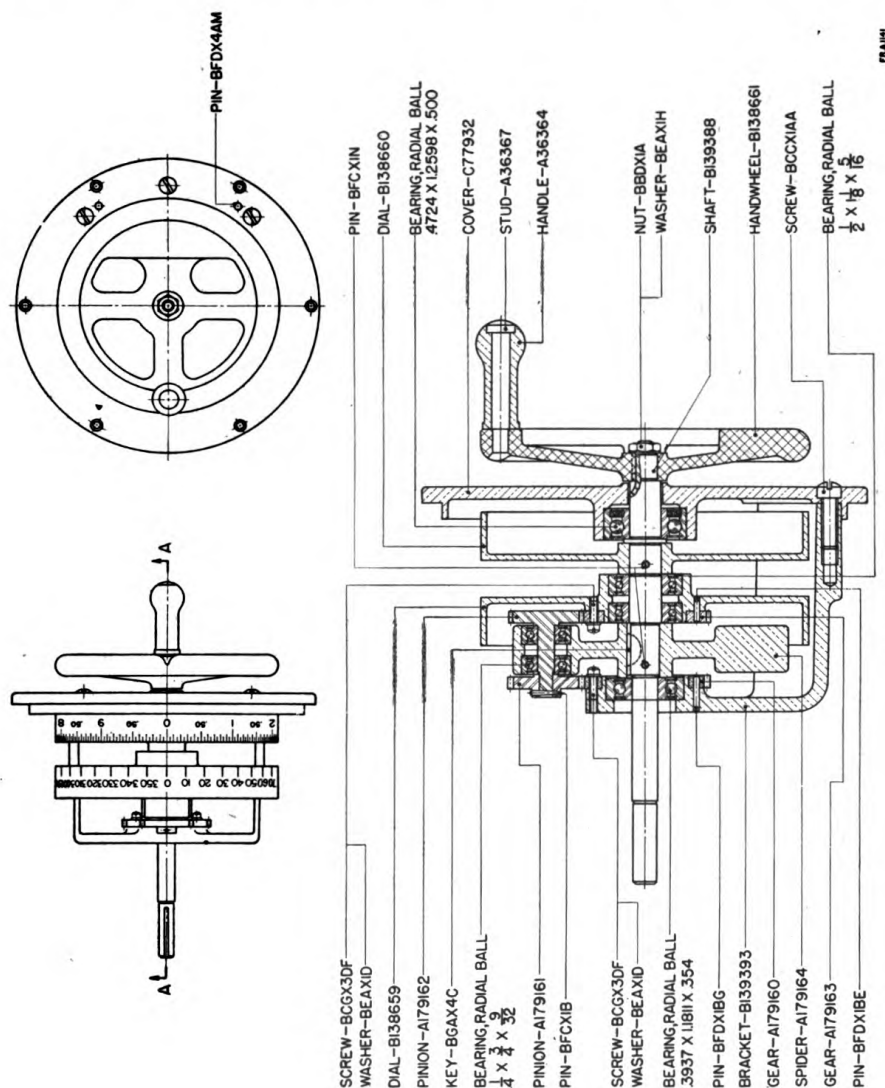
FIGURE 7.—Mirror assembly.

(5) The elbow telescope M10 (fig. 5) is an 8-power erect-image instrument having a field of view of $8^{\circ}45'$ and an exit pupil diameter of 0.136 inch. The optical system (fig. 6) consists of an objective, Amici prism, reticle, and eyepiece assembly made up of an eyelens, field lens and collective lens.

f. Indicator and mirror drive.—Outside and sectional views of the azimuth indicator and mirror drive mechanisms are shown in figures 8, 9, and 13. Identical units are used on the plotting boards M3 and M4.

(1) *Azimuth indicator.*—Referring to figure 8, the indicator consists essentially of a fine and a coarse dial which are interconnected

by means of suitable gearing and driven by a handwheel to indicate azimuth against a fixed index. The fine dial is pinned directly to the handwheel shaft, is graduated from 0° to 10° at 0.05° intervals, and is numbered every 0.50° . The coarse dial is graduated and numbered from 0° to 360° at 10° intervals. It is mounted on an anti-



SECTION A-A
FIGURE 8.—Indicator assembly, counter and handwheel drive.

friction bearing on the handwheel shaft and is geared to rotate at the rate of 10° per revolution of the handwheel. The coupler (12, fig. 13) is keyed and pinned to the handwheel shaft and provides the means for adjusting the position of the mirror (fig. 7).

(2) *Mirror drive.*—The mirror drive mechanism is connected to the azimuth indicator by means of the tube (19) and coupler (12)

as shown in figure 13. The motion of the handwheel is therefore transmitted to the mirror, which is mounted on the upper extremity of the vertical shaft (B139380, fig. 9) in the housing (D43510). The mirror assembly is positioned on the shaft by means of a key (A179177) on the shaft and a keyway in the assembly.

g. Miscellaneous.—(1) The collimating targ (fig. 10) is provided for use in checking and collimating the optical station arm.

(2) A small drawer (fig. 14) is built into the board for holding the targs, mirrors, etc., when they are not in use.

(3) A packing chest is provided for storing the station arms and station arm couplers when they are not in use.

4. Operation.—*a. Comparison.*—(1) The operation of the plotting board M4 is the same as for the M3 board, since they are similar, except that the M4 board has been designed to accommodate the increased range of modern cannon.

(2) In general, the M3 and M4 boards resemble all other standard plotting boards in that they are devices for the graphical representation to a convenient scale of a constantly changing triangle, one side of which is fixed as to length and azimuth. The purpose is to locate the successive positions of the moving vertex of the triangle in the field of operation. The two station arms, or the changing sides of the triangle, represent the line of sight from the observing stations to the target, and the point of intersection of the arms, or the vertex of the triangle, represents the position of the target in the field of operation.

(3) When the single station method of tracking is used, the target is located in the field of operation by its distance from, and azimuth with respect to, one point.

(4) These boards have no special device for the determination of angular travel, such as the gun arm azimuth circle on the Whistler-Hearn type plotting board M1904. Other plotting room devices have been adapted to the use of azimuths of successive plotted points in determining the angular travel of the target for case II pointing. Therefore, the operation of the boards is identical for case II and case III pointing and is similar to the operation of the 110° board and to the operation of the Whistler-Hearn board for case III pointing.

(5) For horizontal base tracking with prediction scale and set-forward device the personnel usually consists of the plotter, two armsetters, and a set-forward device operator. The azimuth of the set-forward point is read by one of the armsetters. For vertical or self-contained base tracking, only one armsetter is required, and

when predicting by means of set-forward scales, the set-forward device operator is not needed, since the plotter locates the set-forward point.

b. Horizontal base.—(1) *Setting up.*—(a) Remove the dust caps (fig. 10) from the station sleeves being used. Select the proper arms from the packing chest and insert the pivots into their respective station sleeves. For this discussion it will be assumed that one arm is a mechanical arm and the other an optical arm. However,

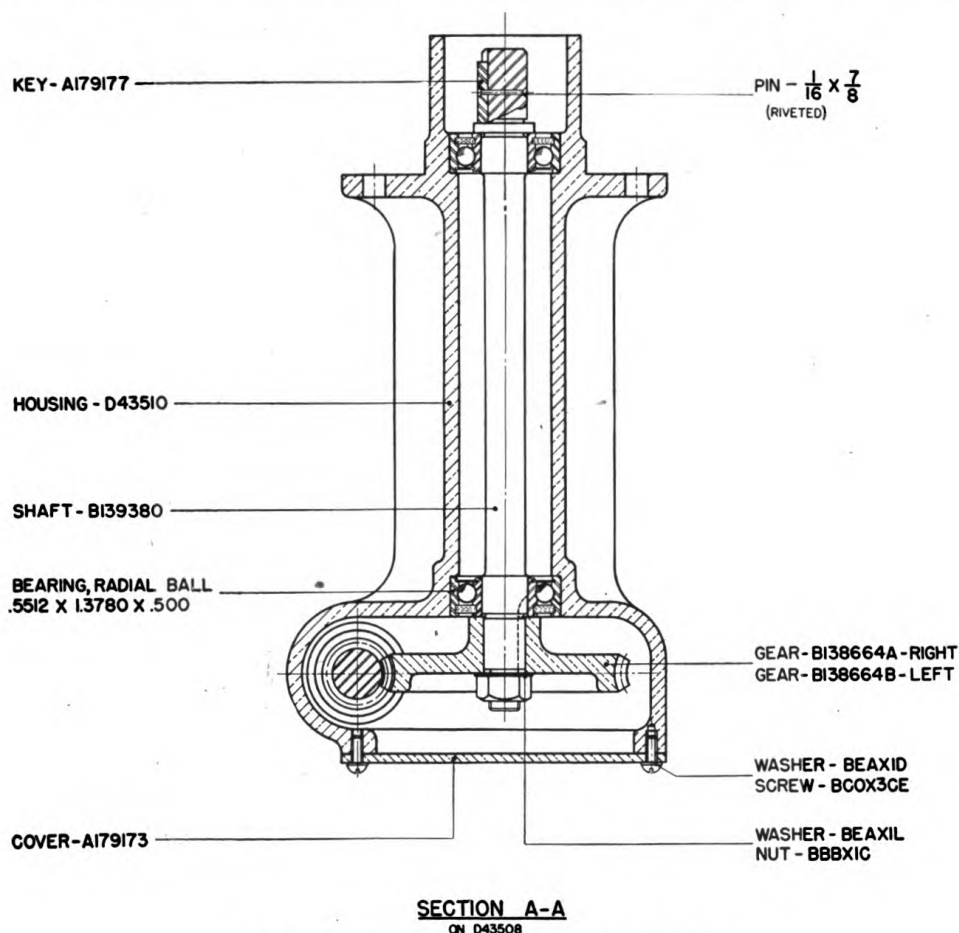


FIGURE 9.—Indicator assembly, mirror drive.

in actual use both arms could be either optical or mechanical, depending entirely on the choice of stations.

(b) Carefully place the mirror assembly in position at the optical station as shown in figure 7.

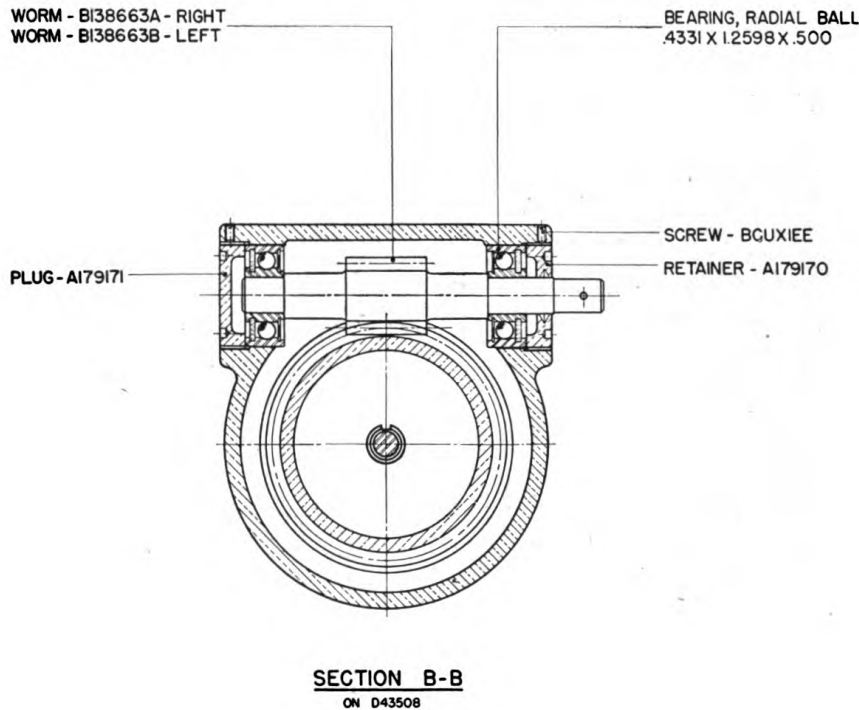
(c) Depress the latch (7, fig. 11) and insert the pivot on the mechanical arm coupler (5) into its socket in the proper index box.

(2) *Tracking.*—(a) Depress the lever (8) and move the index box (6) along the azimuth circle (16) until the azimuth reported

from the observation station is indicated on the azimuth circle and subscale (21).

(b) Turn the azimuth reported from the other observation station on the indicator (10, fig. 13) connected to the optical station in use.

(c) Position the optical arm approximately by moving the arm until the reflection in the mirror of the white line engraved on the arm appears to be a continuation of the actual line. Complete the adjustment by moving the arm until the black reticle line appears



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FIGURE 9.—Indicator assembly, mirror drive—Continued.

to be superimposed upon the reflected image of the broad white line in front of the telescope lens.

(d) Place the plotting targ (13, fig. 11) at the intersection of the fiducial edges of the two arms. The ranges from the two observation stations to the target can now be read.

(e) Without moving the targ, bring the fiducial edge of the gun arm (1) into contact with the knife edge of the targ. It may be necessary to move one or both of the station arms to do this. The range from the gun or directing point can be read on the gun

arm opposite the targ. The azimuth can be read on the azimuth circle and gun arm subscale (15). The azimuth will be the reading on the azimuth circle opposite the subscale, plus the reading on the subscale opposite the graduation on the azimuth circle.

(3) *Set-forward point*.—After at least two, and preferably three, points have been plotted as directed above, a set-forward point may be located. The plotter estimates the expected course of the target and places the edge of the prediction scale along that line with the zero at the last plotted point. He calls out to the set-forward rule operator the travel of the target during the dead time, as indicated by the *plotted points*, and with the targ marks the position of the set-forward point along the edge of the scale, as called out by the operator of the set-forward rule. The rule is constructed to measure the travel of the target during the dead time plus the time of flight.

(4) *Relocation*.—When the first set-forward point is located, the gun arm is swung against the targ held at that point and the plotter reads the uncorrected range, to the point, on the gun arm range scale. He then places a small distinguishing mark at the point to avoid confusion with later plotted points. This operation is repeated for each set-forward point.

c. Vertical and self-contained base.—(1) One station arm is used. The azimuth is set as described in *b* above, depending on whether a mechanical or optical arm is used.

(2) The knife edge of the targ is placed against the station arm at the reported range, and the range and azimuth from the directing point are read in the same manner as described in *b* above.

d. Test problems.—Test problems, data, and assembled views will be furnished with each board according to the serial number of the board.

5. Adjustment.—*a. General*.—The plotting board is accurately adjusted by the manufacturer and with proper care should require no further adjustment at the battery. However, the orientation of the optical arms and related mechanisms may be checked and any necessary adjustments made as explained in *b* below. Any further adjustment of the board should be made by ordnance personnel only.

b. Optical station arms.—(1) Place the optical arm and mirror in position at one of the optical stations. Place the collimating targ (fig. 10) in one of the mechanical station sleeves and engage the optical arm and targ as shown in figure 10. Carefully set the azimuth of the selected base line on the appropriate indicator (10, fig. 13). Check the position of the black reticle line with respect

to the reflected image of the white line on the strip across the front of the objective. If the lines do not coincide, loosen the clamp screw in the coupler (12) and rotate the worm (14) until coincidence is secured. Tighten the clamping screw. Make the adjustment very carefully to avoid disturbing the setting of the indicator. If the lines are not parallel, loosen the screw (BCUX1CC, fig. 5) in the cap (B173791) and rotate the cap until parallelism is secured. Tighten the screw securely.

(2) Repeat the above check for adjustment of the remaining optical stations.

6. Packing and assembling.—*a. Packing.*—(1) Plotting boards of the M3 and M4 type are shipped complete in two packing cases

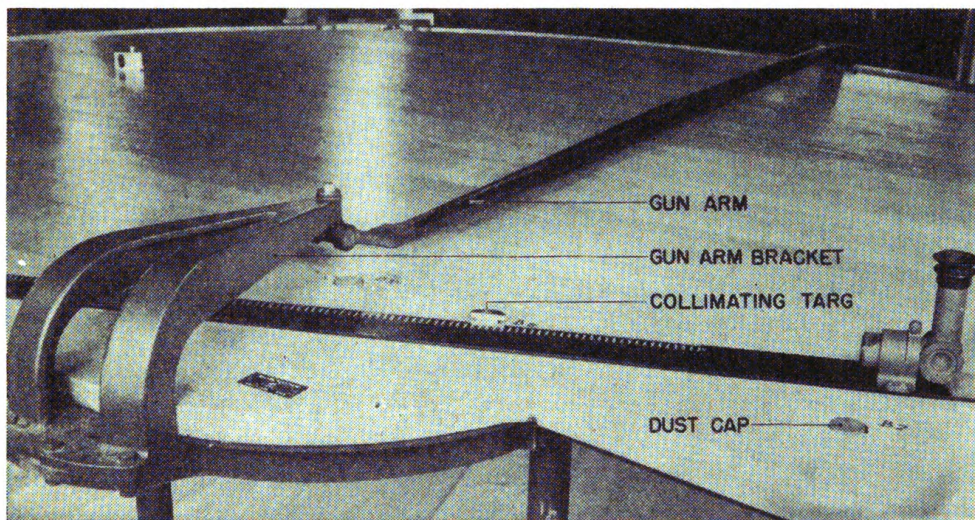


FIGURE 10.—Collimation of optical arm.

which should be kept for future use after setting up the boards. If at any time a board is to be returned to the arsenal for repairs, it should be packed in the cases in the same manner in which it was packed when received.

(2) The station arms, telescopes, and couplers are packed in the smaller packing case, which can be used as a storage chest for the arms when not in use.

(3) The rest of the board, with the exception of the legs, is packed assembled in the larger case. The legs are removed and packed in the bottom of the box in such manner that they cannot work loose. The canvas cover is also contained in this case.

(4) The targs and mirror assemblies are packed in the accessory drawer attached to the bottom of the wooden board.

b. Assembling.—(1) To mount and assemble the board, remove it from the case and support it by any convenient means at a sufficient height from the floor so that the legs can be assembled to the frame. The frame or spider must always be used for lifting and supporting the board. Turn the legs into the threaded holes in the frame and carefully lower the board until its weight is supported on the legs.

(2) Adjust the length of the legs by means of the bases (24, fig. 1) until the azimuth circle levels up. A test level must be used for checking this at assembly and at frequent intervals thereafter.

(3) Select the arms to be used from the smaller packing chest and remove the dust caps from the corresponding station sleeves on the board. Carefully insert the pivots on the arms into their respective sleeves. To avoid bending the arm and binding the pivot, the filler on the end of the arm which crosses over the other arm should be turned underneath.

(4) To assemble an optical arm and its accessories to the board proceed as follows:

(a) Insert the pivot on the arm into the machined sleeve in the upper end of the mirror drive housing, being careful not to bend the arm unnecessarily.

(b) Slip the mirror assembly over the end of the vertical shaft in the mirror drive. The adapter on the assembly will receive the shaft in only one position, so there is no possibility of assembling the parts incorrectly.

(c) Place the objective leg of the telescope in the bracket on the arm, with the lens facing the mirror drive and the eyepiece in a vertical position. (See fig. 1.) Rotate the handwheel on the appropriate counter until the reflected image of the white line on the strip across the objective lens can be seen in the mirror. While observing the reflected image through the telescope, rotate the telescope in the bracket until the reticle line assumes a vertical position. Tighten the clamping screw on the bracket. If the reflected image of the white line is not vertical, or parallel to the reticle line, loosen the screw in the cap (B173791, fig. 5) and rotate the cap until parallelism is secured. Tighten the screw securely.

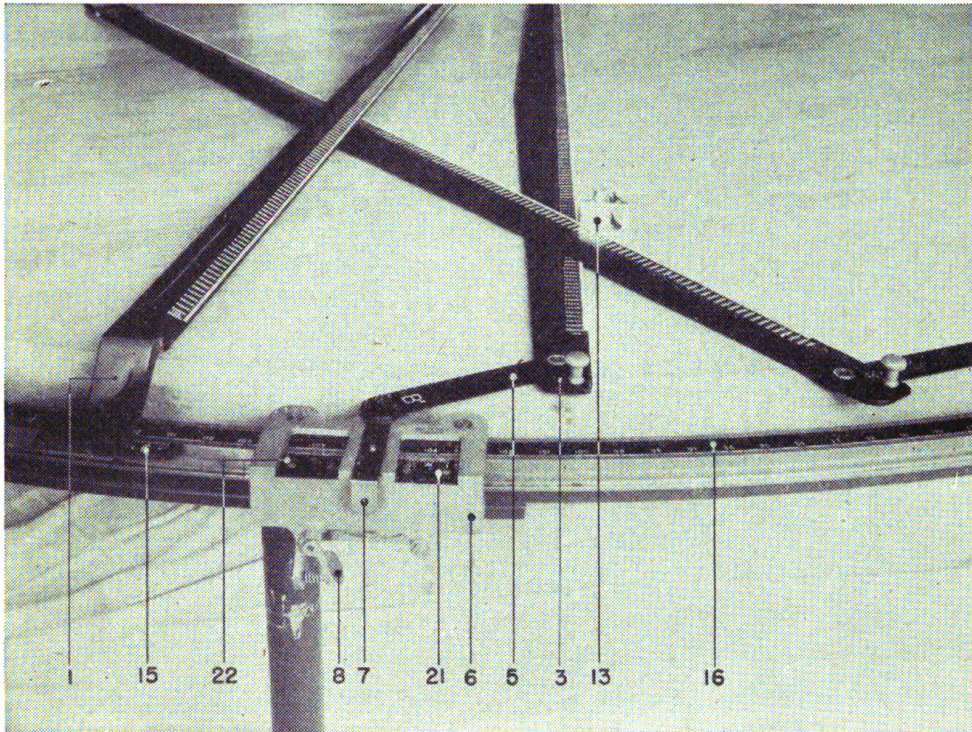
7. Care and preservation.—*a. Arms.*—(1) Care must be exercised to prevent binding or twisting the arms and couplers. Particular care should be exercised in handling the optical arms to avoid disturbing the adjustment of the telescopes.

(2) The arms should be stored in the small packing chest when not in use.

b. Telescopes.—(1) Care must be exercised to prevent bumping the telescopes. They are precision instruments and must be handled as such.

(2) Do not wipe the telescope lenses with the fingers or an oily cloth. Remove dust and grit from the optical surfaces with a clean camel's-hair brush.

(3) To remove oil or grease from the lenses, apply alcohol sparingly with a camel's-hair brush and wipe off with lens tissue. If



- | | |
|----------------------------|-------------------------|
| 1. Gun arm. | 13. Plotting targ. |
| 3. Mechanical station arm. | 15. Gun arm subscale. |
| 5. Station arm coupler. | 16. Azimuth circle. |
| 6. Index box. | 21. Normal subscale. |
| 7. Latch. | 22. Auxiliary subscale. |
| 8. Lever. | |

FIGURE 11.—Plotting boards M3 and M4, gun and mechanical arms and index box.

alcohol is not available, moisten the lens by breathing heavily on it and wipe off as directed above. Repeat this operation until the surface is clean.

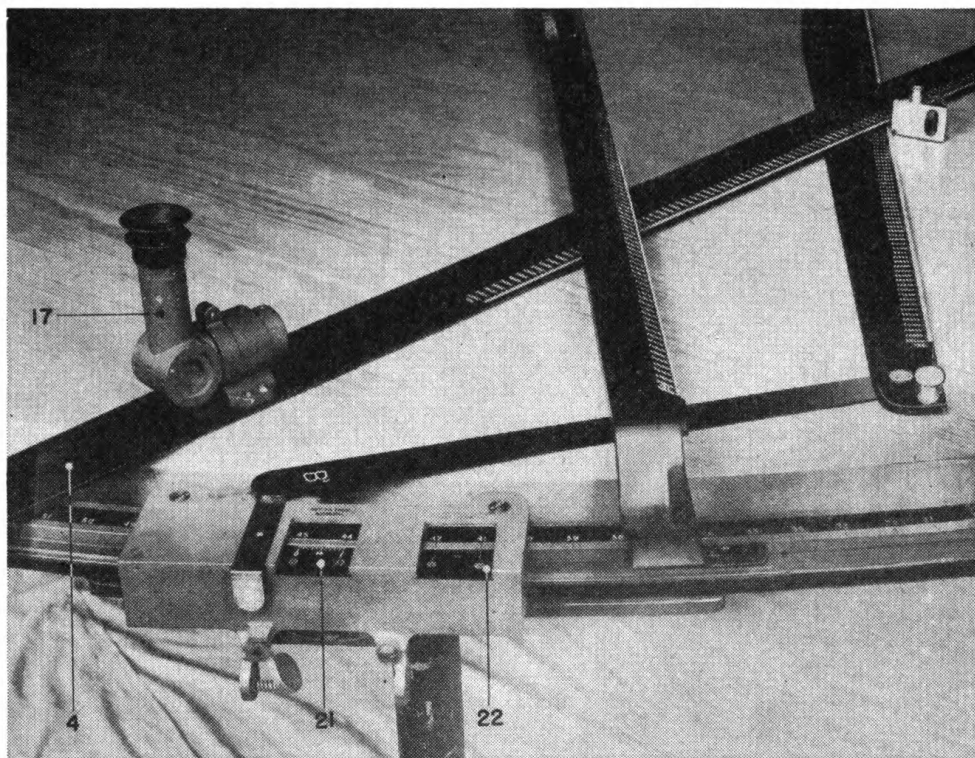
c. Mirrors.—(1) Before removing the optical arm from the board, remove the mirror assembly from its socket by means of the wire ring attached to the assembly. This will prevent damage to the mirror caused by striking it with the pivot of the arm.

(2) Place the mirrors in the drawer in the board when not in use.

(3) Use the same procedure in cleaning the mirrors as in cleaning the telescope lenses.

d. Lubrication.—(1) The station arm pivots and sleeves will be lightly lubricated every 6 months with grease, special, low temperature.

(2) The ball bearings used in the construction of the board are lubricated by the manufacturer on assembly and should require no



4. Optical station arm.
17. Elbow telescope.

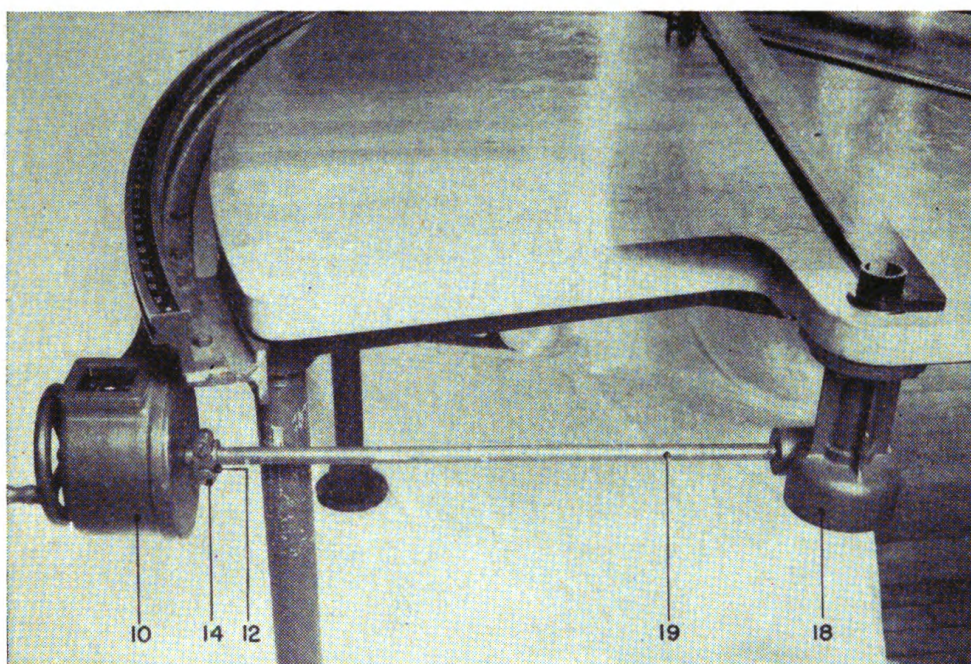
21. Normal subscale.
22. Auxiliary subscale.

FIGURE 12.—Plotting boards M3 and M4, gun, mechanical, and optical station arms and index box.

further attention. If faulty operation occurs, qualified maintenance personnel must make necessary repair and lubrication.

(3) The mirror worm drives are also lubricated by the manufacturer on assembly. Qualified ordnance maintenance personnel will relubricate.

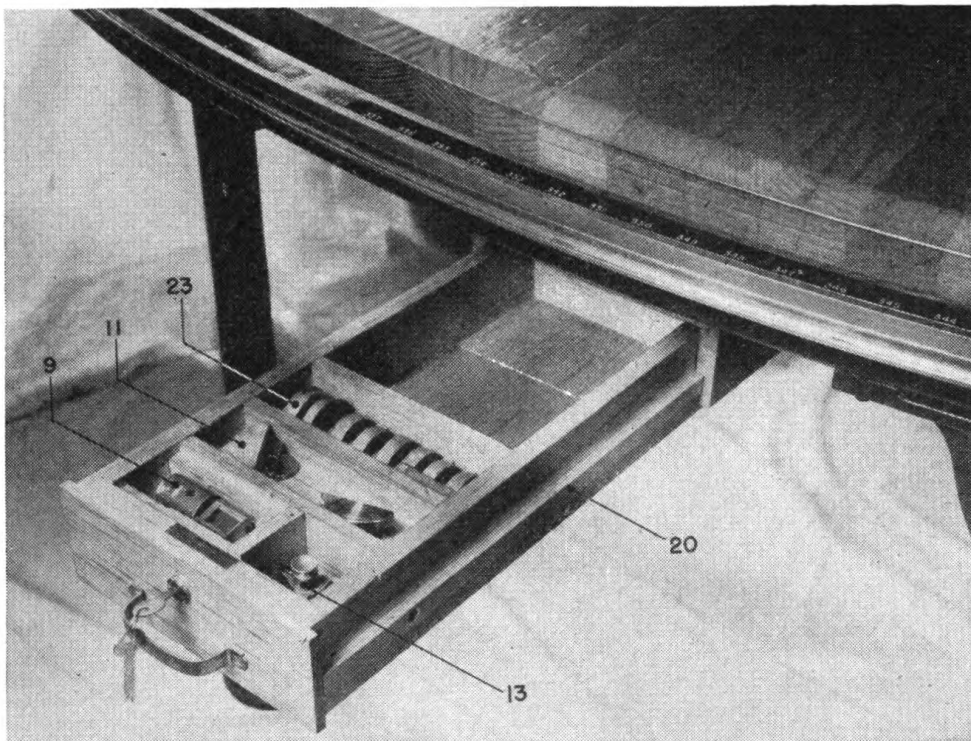
(4) All excess lubricant which might seep out of bearings or worm drive housings will be wiped off to prevent accumulation of dust and grit.



- 10. Indicator.
- 12. Adjustable coupler.
- 14. Worm.

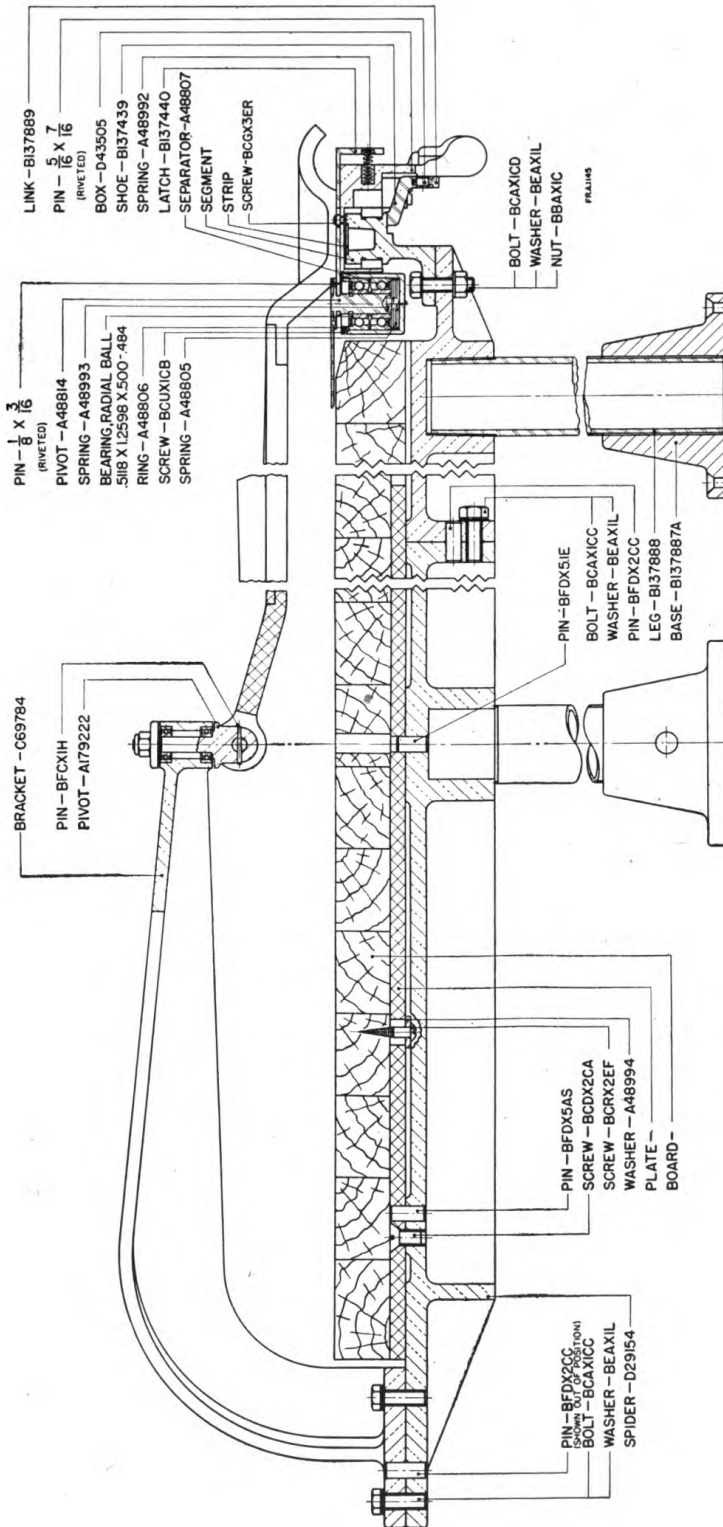
- 18. Mirror drive housing.
- 19. Tube.

FIGURE 13.—Plotting boards M3 and M4, indicator and mirror drive.



- | | |
|-----------------------|-----------------------|
| 9. Mirror assembly. | 20. Accessory drawer. |
| 11. Collimating targ. | 23. Dust cap. |
| 13. Plotting targ. | |

FIGURE 14.—Plotting boards M3 and M4, accessory drawer.



SECTION A-A-A

Figure 15.—Plotting board M4, sectional view.

APPENDIX

LIST OF REFERENCES

1. **Standard Nomenclature Lists.**

Boards, plotting, M3 and M4----- SNL F-185
 Current Standard Nomenclature Lists are as tab-
 ulated here. An up-to-date list of SNL's is
 maintained as the "Ordnance Publications for
 Supply Index"----- (OPSI)

2. **Field Manual.**

Seacoast artillery, fire control and position find-
 ing ----- FM 4-15

[A. G. 062.11 (5-19-41).]

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 (For explanation of symbols see FM 21-6.)

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